Space Weather Technical Forecast

Issued on Sunday 6 October 2024 at 01:10 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: CME imminent, G1/G2 Expected, Chance G3 over remainder of UTC weekend. R1/R2 Expected throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity measured at GOES16 and 18 remained at High levels, again owing to proximity of the background flux to M-class, with any minor increases producing low-level M-class flares (rather than any larger X-class activity). These flares peaked with an M2.4 at 2320UTC from AR3842. Also observed was an M1.6 event at 05/0844UTC, apparently from AR3849 near the eastern limb, although the cadence of observing SDO AIA imagery has been impaired over the period.

There are now seven numbered sunspot groups, with two crossing the western solar horizon and a third fading to plage in the east. The southwest quadrant remains heavily populated with large and complex regions: AR3842 and AR3844 both showed consolidation and slight areal growth of the main leading penumbral spots. A Mount Wilson delta spot remains clear in AR3842, however the penumbrae in AR3844 are perhaps sufficiently separated for the similar feature to have decayed here. Changes in the eastern solar hemisphere were much slower and more limited, with little change observed in AR3848 and AR3849, although the latter may be in part due to the poor viewing angle.

There is a large filament in the south central disc that is currently proud of its underlying magnetic neutral line and has been for some time. Given its location this is something to monitor.

CME activity observed in coronagraphs was generally confined to high latitudes narrowly over the western solar horizon - to no effect at Earth. No new Earth-directed CMEs were in evidence.

Solar Wind / Geomagnetic Activity: The awaited X9.0 CME from 03 October appears to have reached STEREO A as of 05/1943UTC, with a IMF magnitude of 20nT. The shock here is co-aligned with Earth's field, but recent hours have revealed subsequent deviations to negative Bz. This satellite is around 25 degrees ahead of Earth and orbiting at 0.96AU, however given the central location of the CME source (AR3842), the CME front is likely to reach 1AU at a similar time here and on the Sun-Earth line.

ACE EPAM LEMS low energy proton counts have been elevated over much of the past 24 hours, which is initially attributed to a close miss from the 01 October X7 CME, but is now perhaps superseded by the influence inbound X9 CME.

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The solar wind showed a slow regime with a Slightly Elevated speed near 400km/s. The solar wind density was within single figures ppcc, and the IMF showed a undulating trend with a Slightly Elevated peak of 9nT. The north-south component was variable between limits of +/-7nT. The phi angle was negative (towards the Sun).

The net result of the above solar wind measures was provisionally Quiet to Unsettled geomagnetic activity, with an early peak of Kp '3+' in the 00-03UTC interval.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 was at Background levels.

High energy electron flux (greater than 2MeV) observed by GOES16 was at Normal Background to the bottom end of Moderate levels (at diurnal peak). The associated 24-hour fluence was below the Active threshold, roughly level with 2.4e6 observed at 05/2359UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is forecast to be Moderate to High, with occasional M-class flares expected and a chance of isolated X-class flares, most likely from AR3842. Recurrence does not suggest any returning large regions over the eastern limb in the forecast period, however there should now be a slight depopulation of the southwestern quadrant by UTC midweek to slightly reduce the overall flare probabilities by this time.

Solar Wind / Geomagnetic Activity: The main CME arrival of the period is the imminent X9.0-related event from 03 October. In the wake of this is a possible glancing CME impact from an M4.0 flare and filament eruption combination on 04 October, passing 1AU late on Monday 07 October.

The sole fast wind due in the period is that from CH78/+, due on Tuesday 08 October. This may be indistinguishable from the residual enhancements caused by the aforementioned CME arrivals that precede it. The most reliably quiet period should be the very end of the current four-day forecast period (barring any new CMEs).

G1-G2/Minor-Moderate Geomagnetic Storm (Kp 5-6) periods are Expected over the remainder of the current UTC weekend, due to the X9.0 CME's effects. There remains a Chance of G3/Strong Geomagnetic Storm (Kp 7) conditions and even a Slight Chance of isolated G4 (Kp 8) intervals. Geomagnetic activity should then wane into the new UTC working week, but further G1 activity may result from any close pass of the M4.0 CME later on 07 October and from a minor coronal hole on 08 October, with each event probably less impactful than the last.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 is forecast to persist at Background, with a daily Chance of exceeding the S1/Minor Storm threshold should further significant flares occur.

High energy electron flux at GOES16 is expected to soon be further suppressed at GEO due to inbound CMEs, with a limited window for recovery before any fast wind from CH78/+ arrives before midweek. There is a slightly rising Slight Chance of Active fluence within this window

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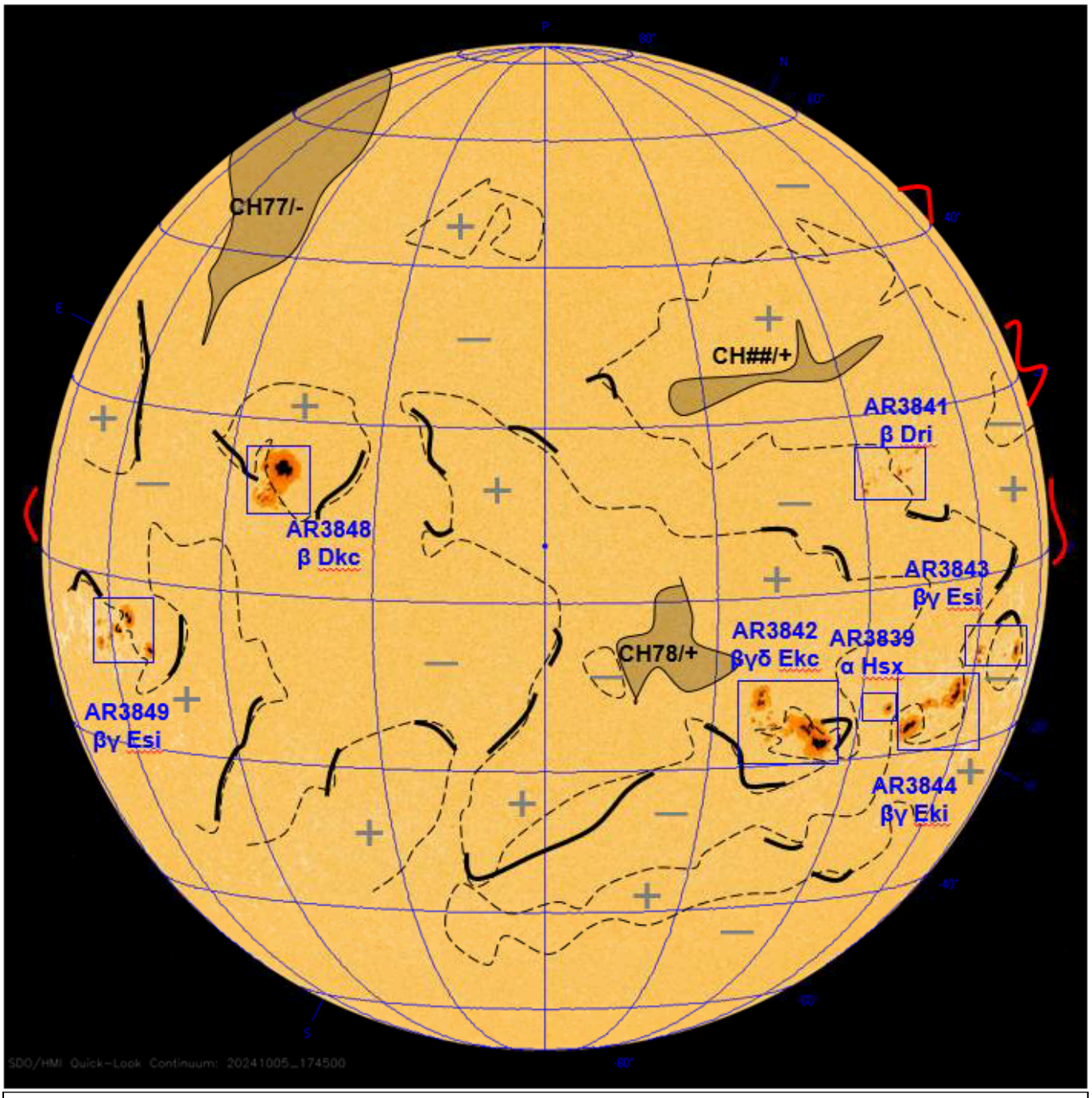
although there remains lower than average confidence overall given the predominance of early CME activity.

Figure 1: Solar synoptic map, valid 05/1745UTC. Much of this map was produced using GONG imagery due to SDO AIA outages at the time of production - with the HMIIF belatedly becoming available.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There is one main CME arrival in the period - the imminent X9.0-related event from AR3842 on 03 October. The previously awaited X7.1-related event considered to have been a close miss (from ACE EPAM LEMS evidence).

In addition to the X9.0 CME, there is perhaps also some minor glancing influence possible from the M4.0-related CME from AR3842 on 04 October, passing 1AU later on Monday 07 October.

The only fast wind in the forecast is likely from small equatorial CH78/+, which may become geoeffective later on Tuesday 08 October, but may be indistinguishable from the residual enhancements caused by the aforementioned CME arrival(s). Speeds for the high speed stream are unlikely to exceed 500km/s.

G1-G2/Minor-Moderate Geomagnetic Storm (Kp 5-6) periods are Expected over the remainder of the current UTC weekend, due to the X9.0 CME's effects. There remains a Chance of G3/Strong Geomagnetic Storm (Kp 7) conditions and even a Slight Chance of isolated G4 (Kp 8) intervals. Geomagnetic activity should then wane into the new UTC working week, but further G1 activity may result from any close pass of the M4.0 CME later on 07 October and from a minor coronal hole on 08 October, with each event probably less impactful than the last.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	95	60	20	5
Strong	G3	No	50	5	1	1
Severe	G4	No	5	1	1	1
Extreme	G5	No	1	1	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
02/0938	Partial	AR3842	SE	800	N/A	Missed Earth
03/1637	Full	AR3842	SW	882	Imminent	Imminent
04/1040	Partial	AR3842 + Filaments	SW	585	07/1800 UTC	Moderate confidence in arrival. Low confidence in timings.

Figure 2: Latest MOSWOC Enlil run and ensemble (badge time 05/1800UTC) paused at the 1AU crossing time of the X9.0-related CME in model space. This verifies very well with observed conditions at STEREO A in recent hours. Using the solar wind speed timeline in the ensemble, the control run (green line) shows respectively from left to right: the X7 CME (missed) the X9 CME (imminent) and a glance from the M4 CME (on 07 October). Any fast wind from CH78/+ is not apparent.

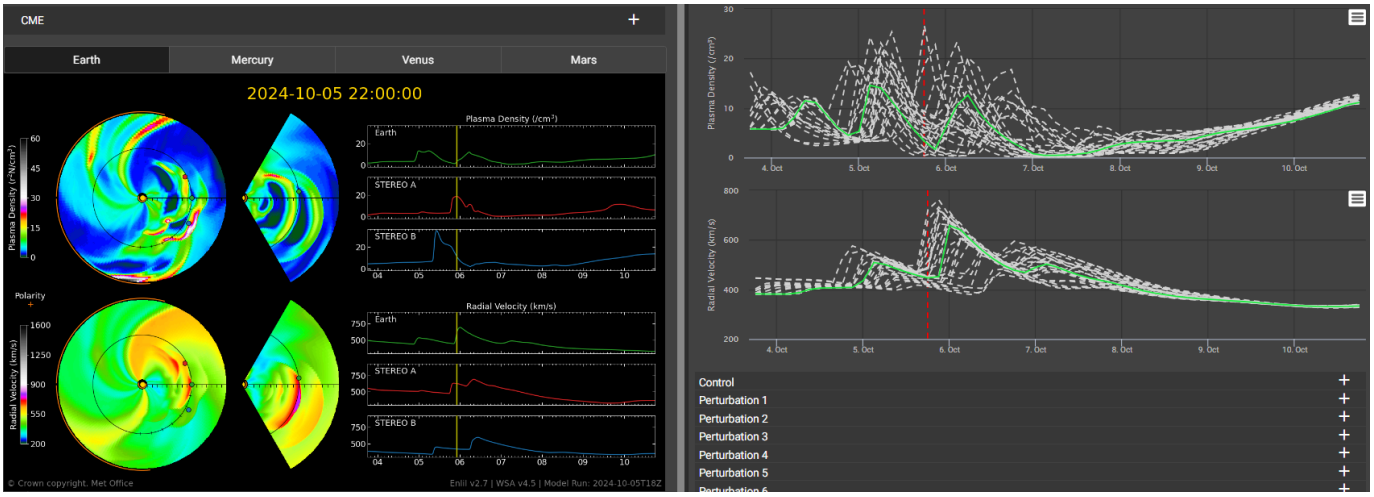

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Figure 3: Past 24 hours of STEREO A MAG measurements to 05/2211UTC, showing a CME arrival at 05/1943UTC that is thought to be the awaited X9.0 CME from 03 October.

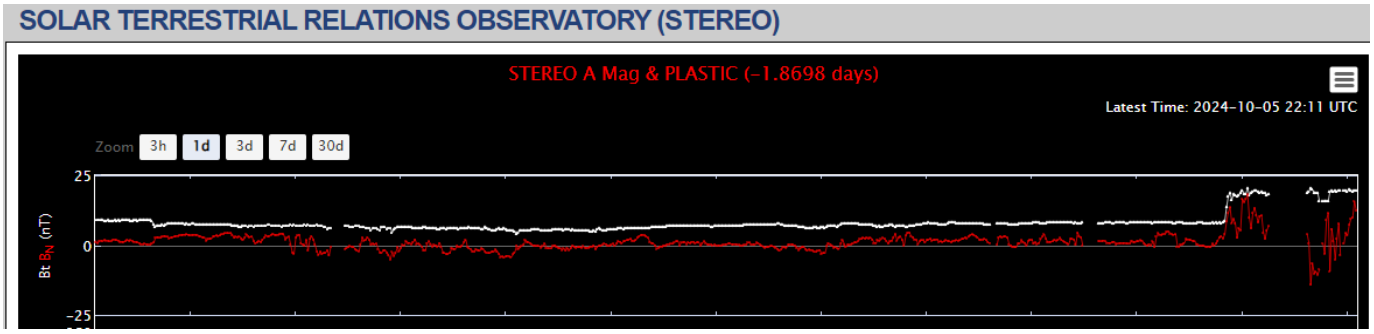
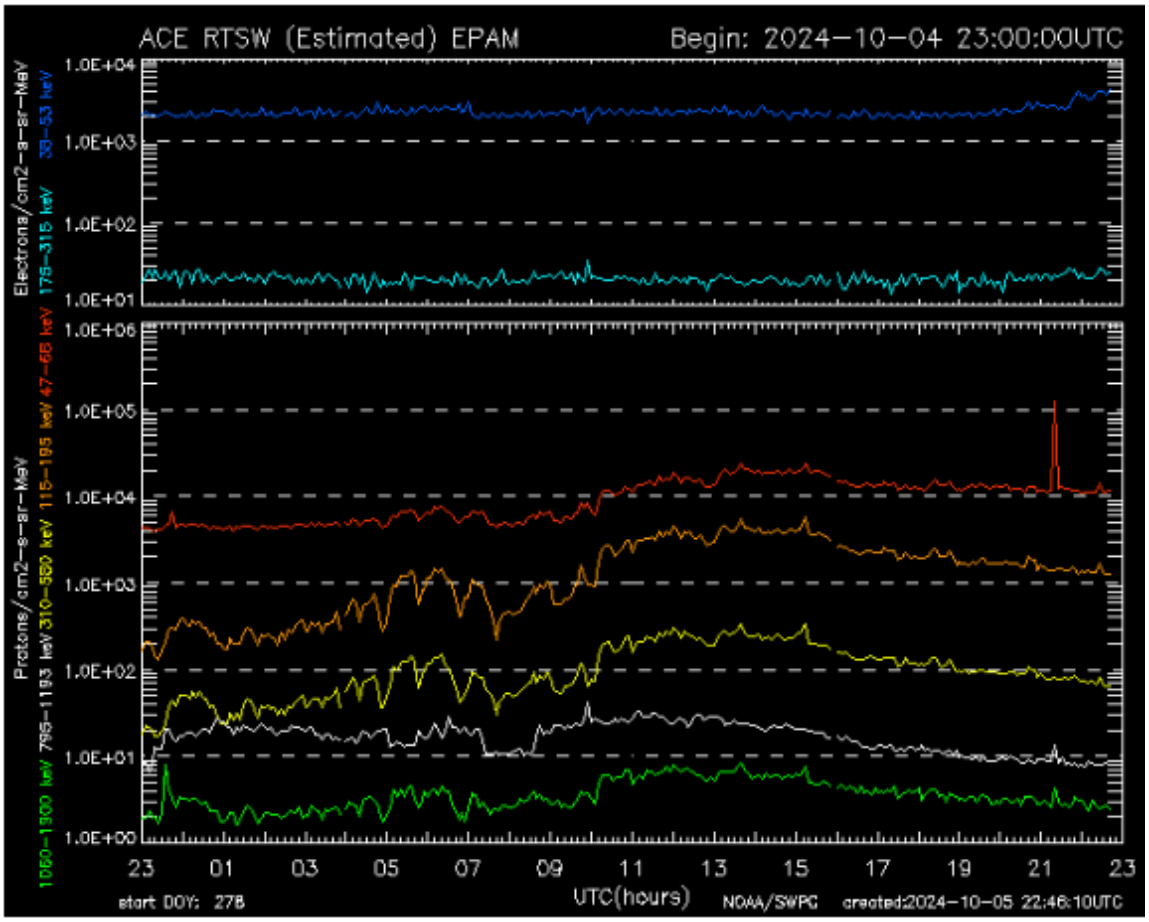


Figure 4: ACE EPAM LEMS for 24 hours preceding 05/2300UTC showing enhanced levels thought to correspond to a close pass from the 01 October X7-related CME (not detected at Earth). The traces are expected to imminently accelerate with the arrival of the X9.0 CME into 06 October.



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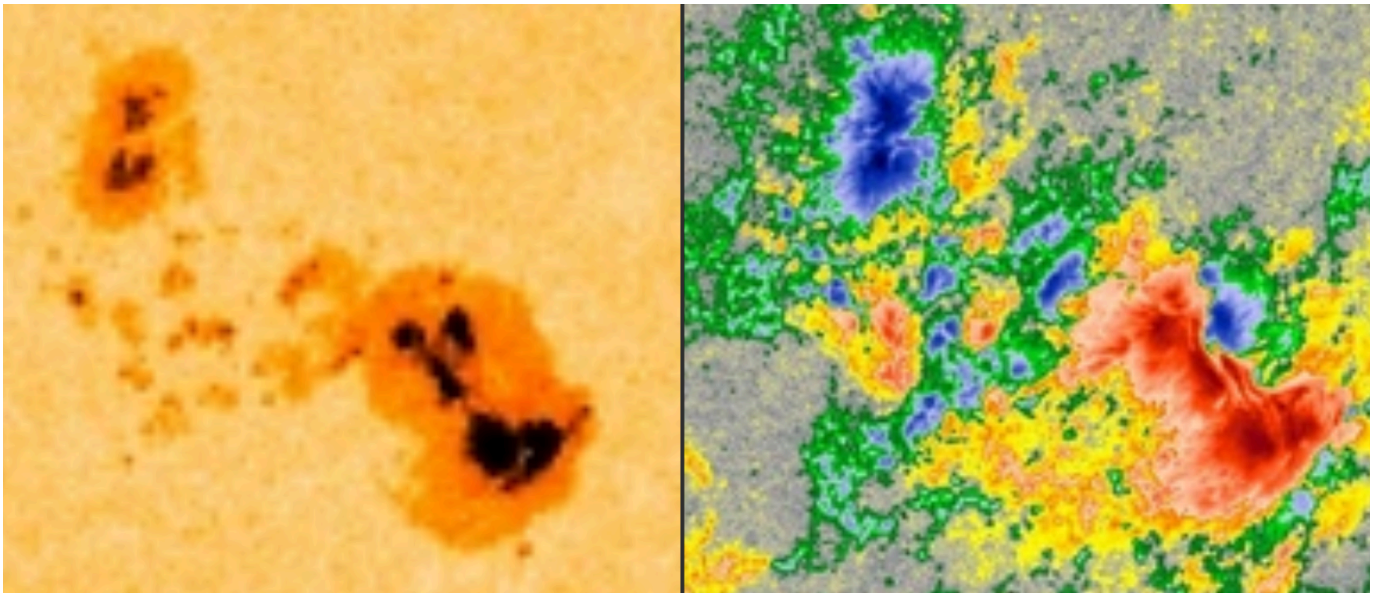
Radio Blackouts - X-Ray Flares

Far side helioseismographs and returning Carringtons due in the period suggest that there are no significant inbound complex regions in the coming four days. The main consideration for X-ray flare risk is therefore any simplification (or intensification) of the current crop of active regions, as well as the gradual depopulation of the southwestern quadrant. AR3843 and AR3844 should rotate off in turn towards UTC midweek, and there is a resultant slight decrease in the probabilities of significant flares. Even with these departures, the risk of flares remains high due to the continuing presence of AR3842 and its large Mt Wilson delta spot.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	90	90	85	80
Very Active	R3-R5 (X Class)	No	25	25	25	20

Figure 5: HMIIF and HMIBC imagery of AR3842 at 05/2230UTC showing large Mount Wilson delta spot in its northwest central portion and a relatively sheared appearance of its leading umbrae.



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Solar Radiation Storms (High Energy Protons)

High energy proton flux at GOES18 has thus far failed to respond to any of the recent large flares, however this still becomes more likely with the sunspots' western advance. So, while modulated versus raw probabilities for the current disc, there remains a daily Chance of S1+, mainly from AR3842. The risk of S1 may begin to moderate slightly as AR3843 and AR3844 rotate off the Earth-facing side towards UTC midweek.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	25	25	25	20
Very Active	**≥ S3 ***	No	5	5	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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Figure 6: Past week in GOES16 X-ray flux and resultant GOES18 high energy proton flux, with the latter unmoved despite numerous centre-disc M and X-class flares.

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High Energy Electrons (≥ 2MeV)

High energy electron flux (greater than 2MeV) observed by GOES16 was at Normal Background to Moderate levels. Forecast CMEs are likely to cause flux at GEO to reduce in the near-term, and the extent of any recovery (before the onset of the sole fast wind in the period on Tuesday 08 October) is also low confidence.

Overall, there is perhaps a slight chance of this window being large enough to allow for a brief period of Active 24-hour integrated fluence in the period - before again being attenuated. Any lasting recovery will probably therefore not come until later in the coming UTC working week.

MOSWOC REFM is not likely to offer a useful steer as to electron populations given the dominance of CMEs in the forecast.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ 1×10^{8}**	No	1	1	5	1
Very Active	**≥ 2 MeV ≥ 1×10^{9}**	No	1	1	1	1

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Figure 7: Past rotation in GOES16 high energy (greater than 2MeV) electron flux (top) and resultant 24-hour integrated electron fluence. The relevant analog for the current time showed no exceedence of Active, although the driving coronal hole is expected to be marginally more intense on this occasion.

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